

Periodic Table Trends

Pre-AP

Target Words

- Valence Electron
- Alkali Metals
- Alkali Earth Metals
- Halogens
- Transition Metals
- Lanthanides
- Actinides
- Noble Gases
- Metal
- Nonmetal
- Metalloids
- Group
- Period
- Periodic Law
- Chemical/Physical Properties and Changes

Periodic Table History

- Atoms; Who was it that proposed the first scientific atomic theory?
- John Dalton – Where did all his empirical evidence come from?
- Atomic Weights – Relative weights in most cases.

Periodic Table History

- Atomic Weight was a big deal, several scientists made their names by compiling lists of weights.
- By the mid 1800's 70 or so elements had all been discovered and weighed, with some disagreement.
- Unfortunately, part of the problem was the several systems of notation and weights being used.

Karlsruhe Congress

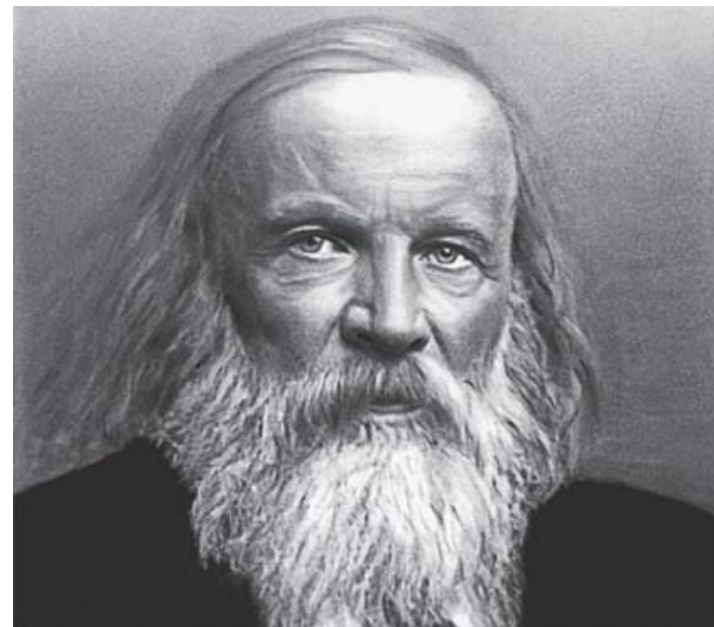
- In 1860 some of the most prominent chemists in Europe called together the first international chemistry conference in Karlsruhe, Germany.
- Issues involving nomenclature, notation, and other topics were considered highly important.
- For example, acetic acid was represented by no less than 19 different proposed formulas!

Karlsruhe Congress – Weighty Matters

- Perhaps the most important item was working on standardized atomic weights.
- Thanks have to go to Avogadro for some really important work and papers that he had released.
- By the end of the Congress, values for important elements were adopted as standard.
 - Hydrogen – 1
 - Carbon – 12
 - Oxygen – 16

Enter Mendeleev

- Russian Chemist, famously wrote *Principles of Chemistry* and in 1869 presented to the Russian Chemical Society his first draft of his extended **periodic table**.
- His table not only arranged the elements known at the time, but also predicted elements not yet discovered!



Mendeleev's Table

Reihen	Gruppe I. — R ⁰	Gruppe II. — R ⁰	Gruppe III. — R ⁰ ³	Gruppe IV. RH ⁴ R ⁰ ⁴	Gruppe V. RH ⁵ R ⁰ ⁵	Gruppe VI. RH ⁶ R ⁰ ⁶	Gruppe VII. RH R ⁰ ⁷	Gruppe VIII. — R ⁰ ⁸
1	II=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,8	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

Mendeleev's Table

- Elements were placed in vertical columns according to **atomic mass numbers**
- Similar properties and characteristics seemed to repeat in certain patterns.
- These patterns were dubbed **periodic** patterns.
- Using these patterns he rearranged the table to put properties in alignment, hence **periodic table**.
- Blank spaces were left to make room for undiscovered elements.
- Naturally, we discovered and filled those in!

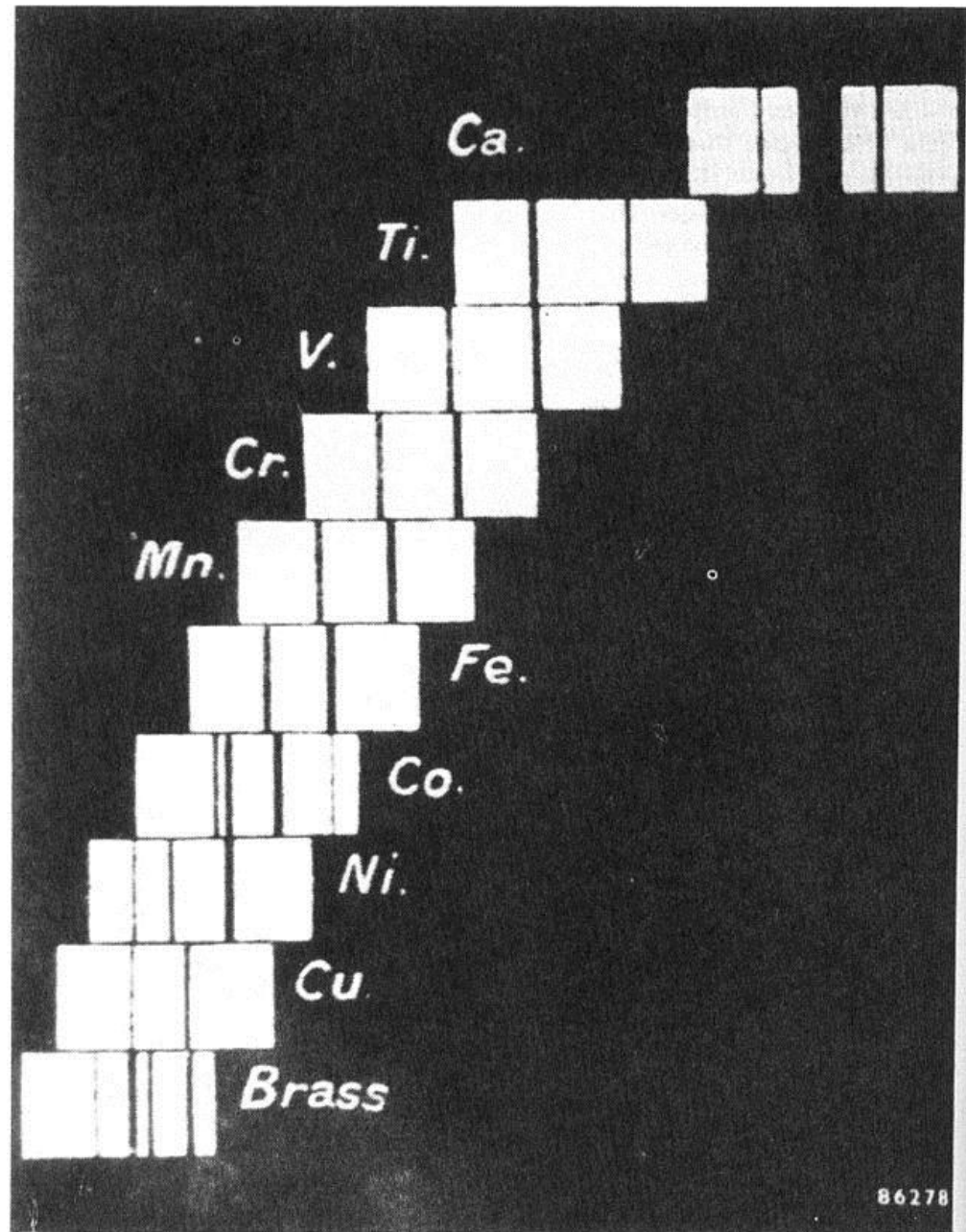
Moseley Cleans Up

- Henry Moseley, British Physicist
- Used early X-Ray diffraction techniques to refine our understanding on atomic structure and atomic numbers.
- He actually demonstrated that atomic numbers were not just assigned, but had a link to X-ray spectra! (Moseley's Law)
- Using this new information he re-arranged Mendeleev's Periodic Table into a more modern format, **by number** instead of weight.
- Naturally his new organization left gaps were filled in by future chemists.



Spectra Lines

- What relationships can you see when you look at your periodic table and these X-ray plates? Is there a connection?



Exercise

- Make a timeline of events including the publication of atomic theory, standardization of weights, and the development of the periodic table.
- Draw a sketch of the periodic table, and fill in the trend lines we learned about.
- How do all these trends interact? How are they connected? Draw an excellent concept map.

Major Families

- Elements on the Periodic Table are arranged in **Families**.
- **Families** are grouped together because they have similar properties and characteristics.
- Why are they similar? Why do they share properties?
- Does it have to do with their configurations?

Metals

- Mostly silver/gray colors, with the exception of Cu and Au.
- Mostly solid, except for Hg, which is a liquid.
- High melting points, generally above 800 degrees C.
- Excellent conductors of heat and electricity.
- Misc. Physical – Very shiny/lustrous when polished, highly malleable and ductile.
- Reactive with Acids.
- Found in Groups 1-12, some in 13-16 under the step line

Non-Metals

- Highly variable colors.
- Solids and gases, except for Br.
- Low melting points.
- Poor conductors of heat and electricity.
- Very dull, brittle, often powdery.
- Not reactive with Acids.
- Found in Group 18, some in 14-17 above the step line.

Metalloids

- Silvery gray to black.
- Solids at room temperature.
- Variable melting points.
- Not good conductors of heat and electricity by themselves.
- Toes the line between metal/nonmetal.
- Reactions with acids vary.
- Found along the step line in Groups 13-17.

Alkali Metals

- Usually gray-white.
- Solids at room temperature.
- Low melting points.
- Not good conductors of heat and electricity.
- Considered metals.
- Extremely reactive! Never found freeform in nature, but is always in important compounds.
- Found in Group 1.

Alkaline Earth Metals

- Usually gray-white.
- Solids at room temperature.
- Low melting points.
- Not good conductors of heat and electricity.
- Considered metals.
- Almost reactive as the alkali metals. Harder and denser and stronger than the alkalis too. These are found throughout the Earth's crust.
- Found in Group 2.

Transition Metals

- Silvery Gray.
- Solids at room temperature, except Hg.
- High melting points.
- Good conductors of heat and electricity.
- Considered metals, obviously.
- High luster, very dense and very strong.
- Less reactive than the alkali/alkaline metals.
- Found in Group 3-12.

Halogens

- Various colors.
- Gases, except Br.
- Non-metals.
- Very reactive, often makes salts.
- Found in Group 17.

Noble Gases

- Gases.
- Light up in fun colors.
- Non-metals.
- Least reactive of all the elements!
- Found in Group 18.

The families

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																																																				
1 H Hydrogen 1.00794	Atomic # Symbol Name Atomic Weight																2 He Helium 4.002602																																																																																				
3 Li Lithium 6.941	4 Be Beryllium 9.012182	<div style="display: flex; justify-content: space-around;"> <div style="border: 1px solid black; padding: 5px;"> C Solid </div> <div style="border: 1px solid black; padding: 5px;"> Hg Liquid </div> <div style="border: 1px solid black; padding: 5px;"> H Gas </div> <div style="border: 1px solid black; padding: 5px;"> Rf Unknown </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="border: 1px solid black; padding: 5px;"> Metalloids </div> <div style="border: 1px solid black; padding: 5px;"> Other nonmetals </div> <div style="border: 1px solid black; padding: 5px;"> Halogens </div> <div style="border: 1px solid black; padding: 5px;"> Noble gases </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> <div style="border: 1px solid black; padding: 5px;"> Alkali metals </div> <div style="border: 1px solid black; padding: 5px;"> Alkaline earth metals </div> <div style="border: 1px solid black; padding: 5px;"> Lanthanoids Actinoids </div> <div style="border: 1px solid black; padding: 5px;"> Transition metals </div> <div style="border: 1px solid black; padding: 5px;"> Post-transition metals </div> </div>														5 B Boron 10.811	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797	11 Na Sodium 22.98976...	12 Mg Magnesium 24.305	13 Al Aluminium 26.9815386	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948	19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955912	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938045	26 Fe Iron 55.845	27 Co Cobalt 58.933195	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.63	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.293	55 Cs Caesium 132.9054...	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)	87 Fr Francium (223)	88 Ra Radium (226)	89-103	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (271)	107 Bh Bohrium (272)	108 Hs Hassium (270)	109 Mt Meitnerium (276)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (280)	112 Cn Copernicium (285)	113 Uut Ununtrium (284)	114 Fl Flerovium (289)	115 Uup Ununpentium (288)	116 Lv Livermorium (293)	117 Uus Ununseptium (294)	118 Uuo Ununoctium (294)

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

These down here are not quite in our scope.

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.5	67 Ho Holmium 164.93032	68 Er Erbium 167.259	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.054	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.03806	91 Pa Protactinium 231.03688	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Periodic Law

- When elements are arranged in order of increasing atomic number, there is a periodic pattern in their physical and chemical properties.
- There are numerous trends in the periodic table dealing with several different factors.
- You will need to know four of these trends and the reasons why they exist.

Periodic Trends

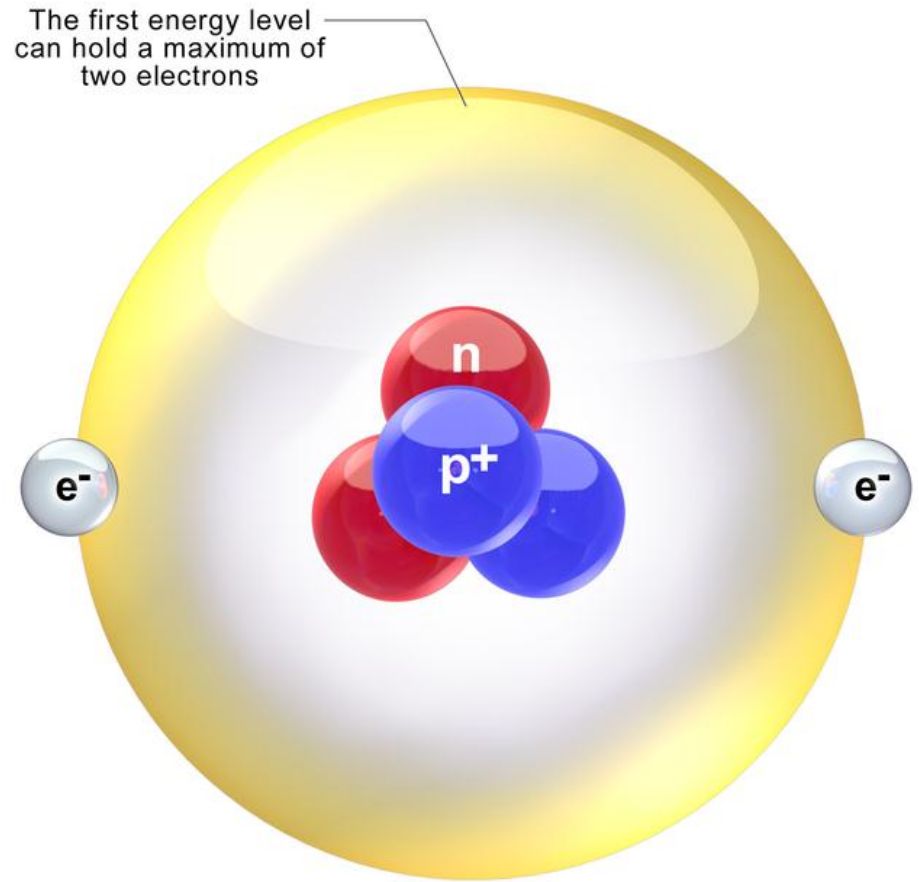
- Atomic Radius
 - How big is the atom? (Tricky Question)
- Ionic Radius
 - How big is an atom *when it is an ion*?
- Electronegativity
 - How strongly will this atom attract electrons?
- Ionization Energy
 - How much energy does it take to remove electrons?

Getting Real with Atoms

- What do atoms look like? What defines the boundaries?
- Atoms are not solid balls of matter. The line between atom and empty space is fuzzy.
- The nucleus is solid, but the electrons are in a cloud of potential places.

What do Atoms look like?

- We are used to seeing something like this;
- However, this is a simplified model designed to be easily read and printed on a page.
- Electrons do not have neat little orbits that can be easily measured and marked for us.



Helium, He

Atomic number: 2

Mass number: 4

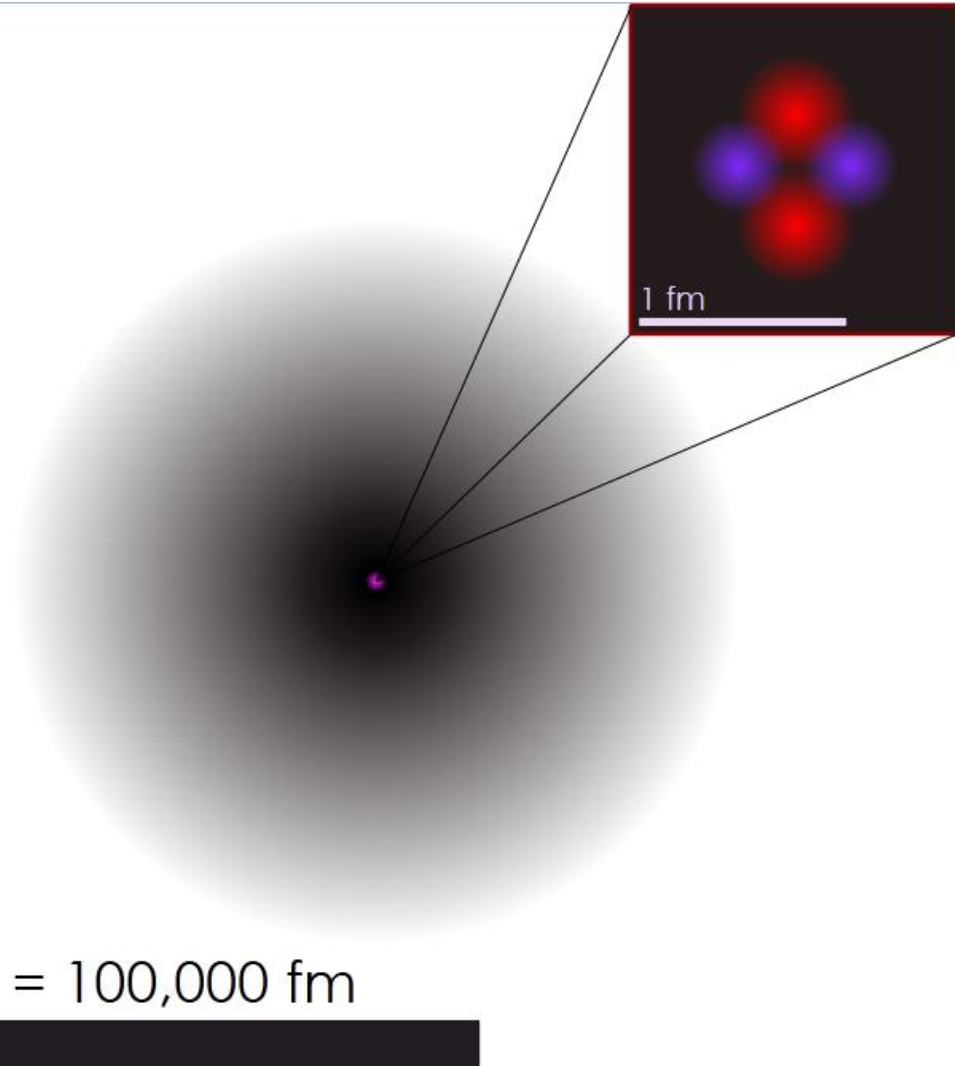
(2 protons + 2 neutrons)

2 electrons

The Real Deal

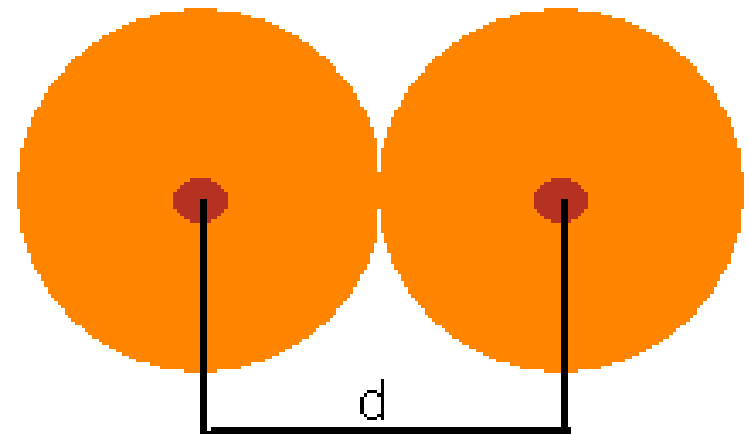
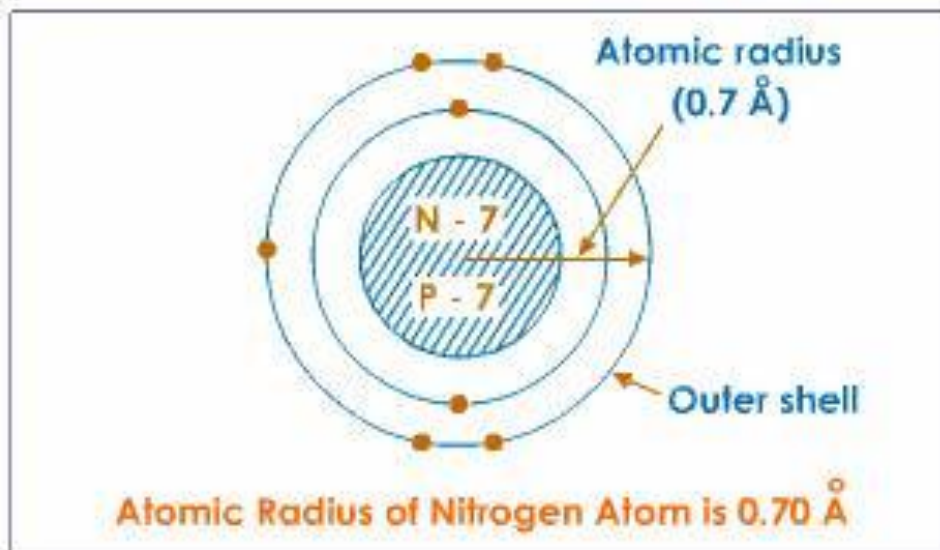
- This is a computer drawing made from data gathered about an atom of helium.
- That tiny dot in the center is the nucleus.
- The cloud is all the places you would detect those two electrons – the darker, the more likely they are to be there.
- The boundaries of an atom are not so clear-cut!

1 Å = 100,000 fm



Atomic Radii

- How do we define it? Two options;
 - The distance from the atomic nucleus to the outermost stable electron shell in a neutrally charged atom
 - Half the distance between nuclei of atoms of the same element that are covalently bonded



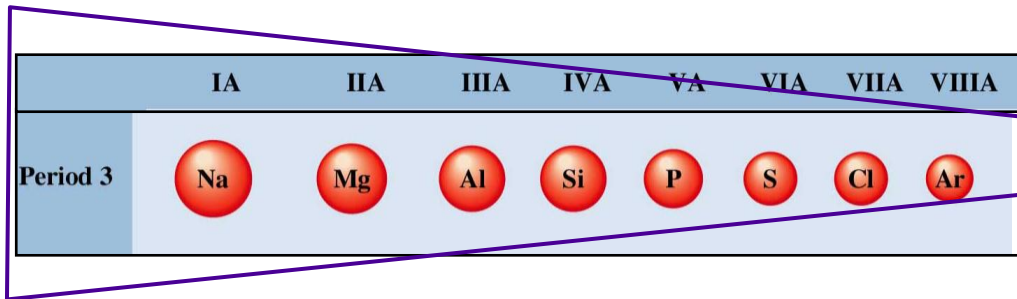
$$r = d/2$$

So.....those trends?

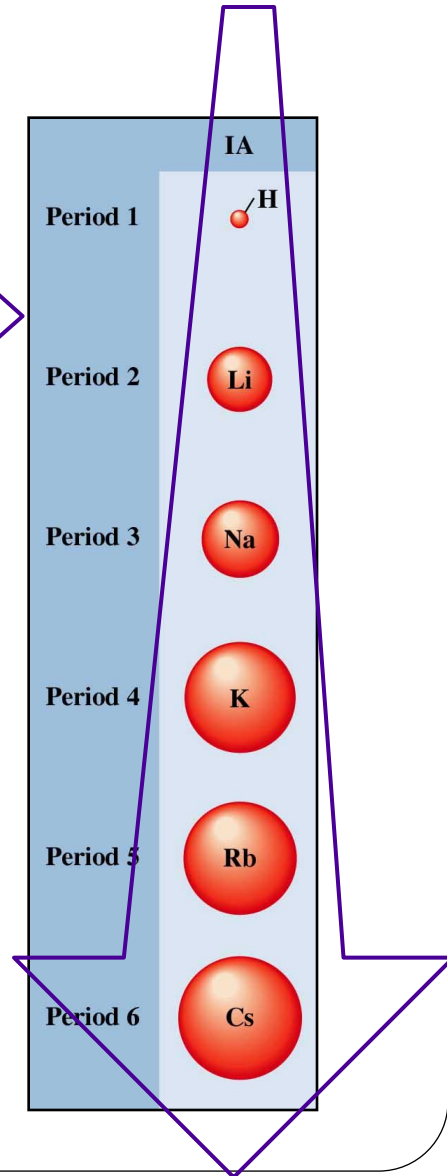
- Hold on – two important concepts are key here!
- First, **Nucleus Strength** – as the number of protons and neutrons in the nucleus increases, they can attract and hold on to electrons more strongly!
 - Bigger nucleus, more pull!
- Second, **Shielding** – electrons work together to ‘block’ or disperse the pull of the nucleus, the more electrons, the more they can weaken the pull of the nucleus.
 - More electrons, less pull!

Atomic Radius Trends

- Across **periods**, the atomic radius decreases!

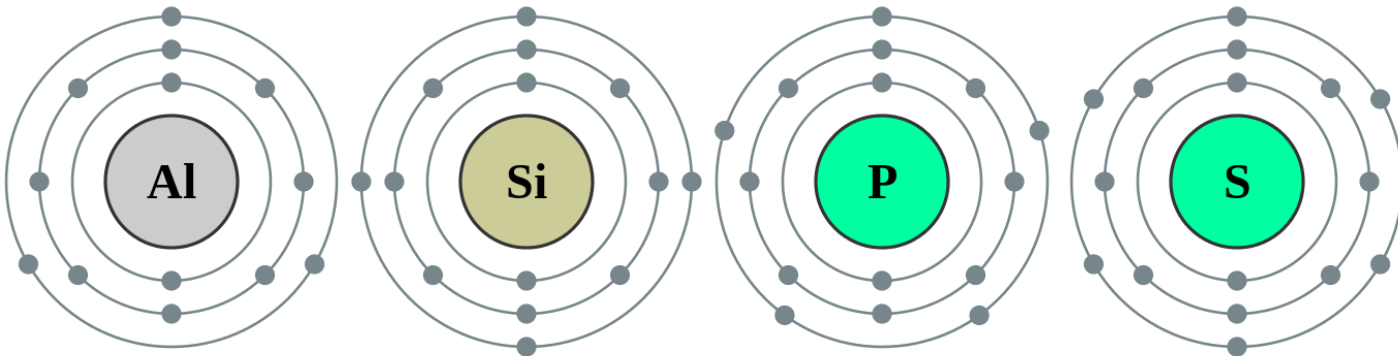


- Down **groups**, the atomic radius will increase.
- Why? It has to do with the interactions of the nucleus and the electrons!



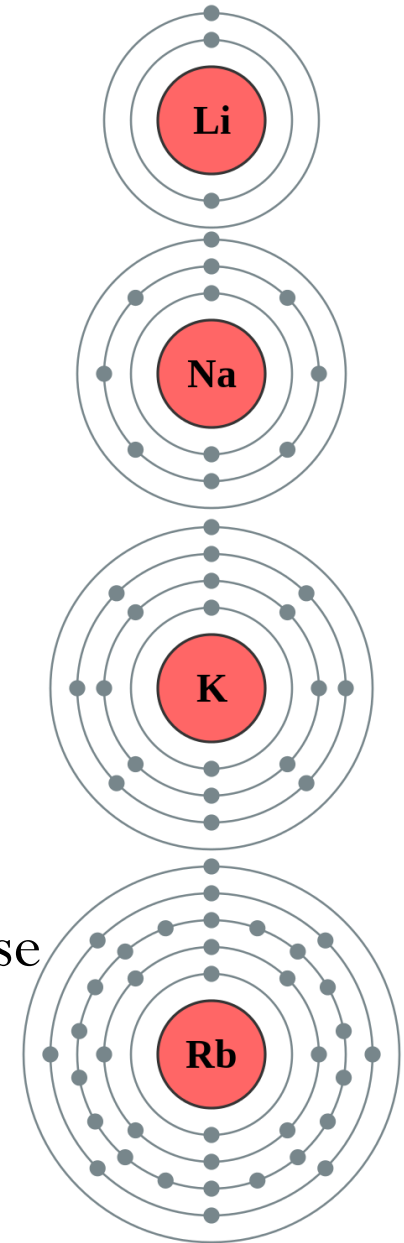
Atomic Radius Explained

- Across a **period** each element is gaining more electrons and protons. Where are they going?
 - Protons (and neutrons) are filling the nucleus up.
 - Electrons are filling up the electron shells.
- However, the electrons are not filling up a **new**, more distant shell!
- So the denser nucleus has a pull that increases faster than the electron's push – with a stronger pull, the electrons are forced closer!

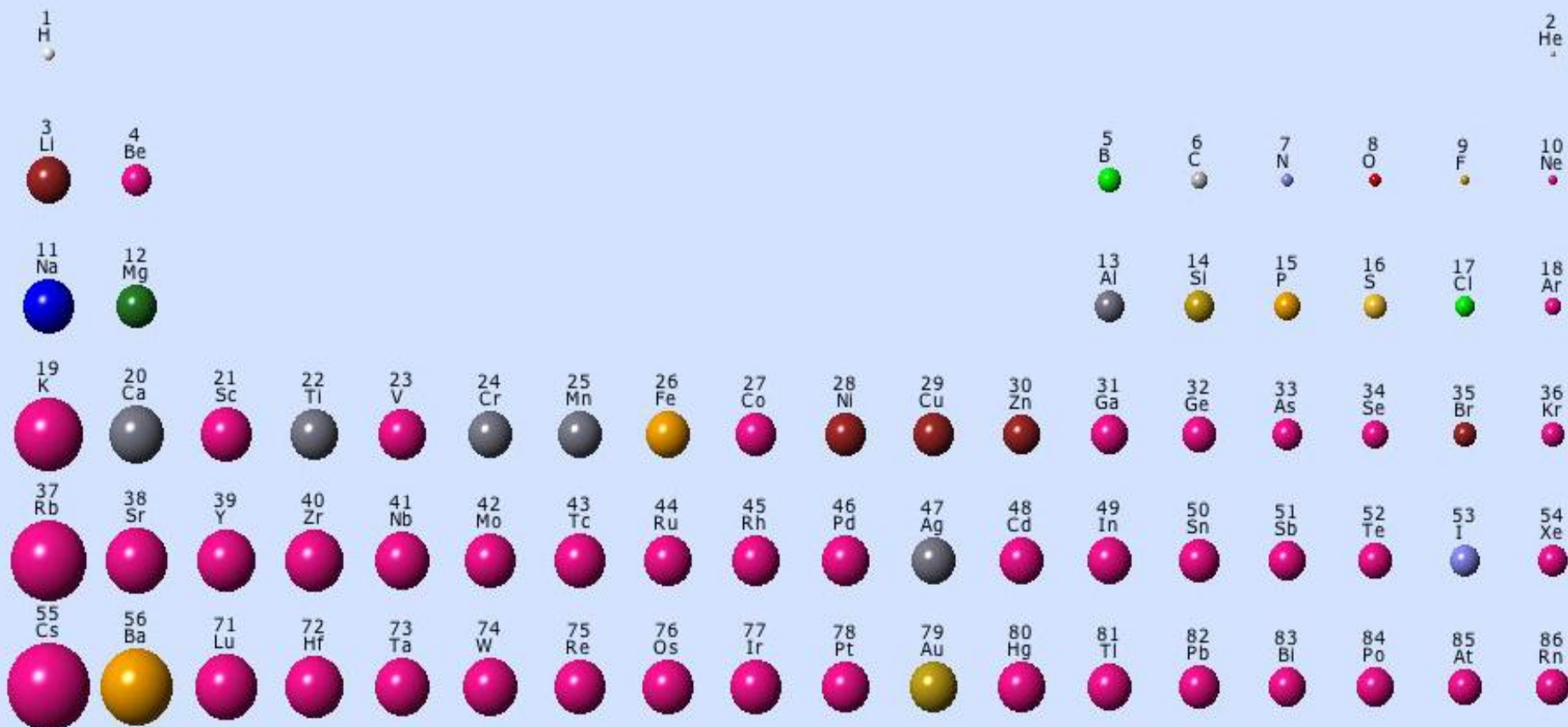


Atomic Radius Explained

- Down a **group** each element is gaining more electrons and protons. Where are they going?
 - Protons (and neutrons) are filling the nucleus up.
 - Electrons are filling up the electron shells.
- This time, the electrons are forced into **new**, more distant shells.
- While the nucleus is becoming more dense, the electrons are forced further and further away because the inner electron shells ‘block’ and ‘push them out- they cannot get closer.



Atomic Radius Illustrated



Ionic Radius Explained

- Ions are the results of losing or gaining electrons. Gains/losses of electrons change the balance of **push/pull**.
- When an atom gains electrons and becomes **negatively** charged, the other electrons get a stronger 'blocking' bonus and push further from the nucleus.
- When an atom loses electrons and becomes **positively** charged, the other electrons lose their 'blocking' bonus and get pulled closer.

Cations

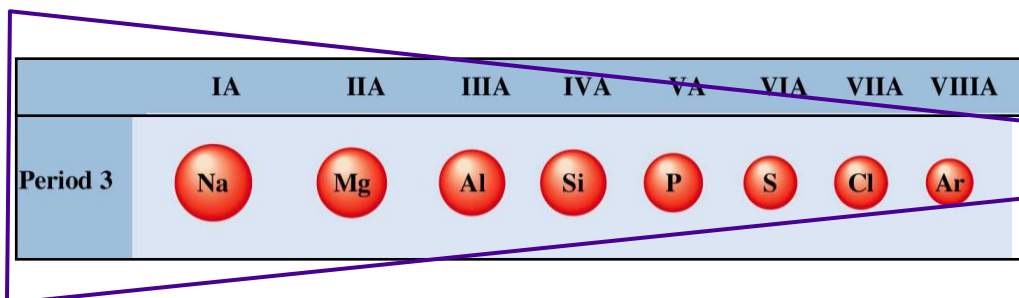
Cramped

Anions

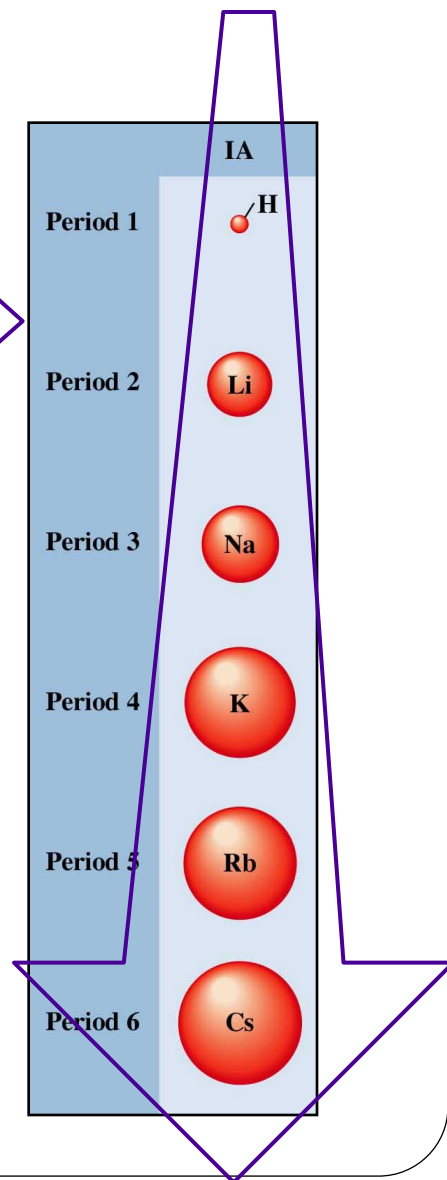
Apart

Ionic Radius Trends

- Across **periods**, the ionic radius decreases!




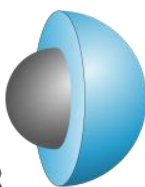
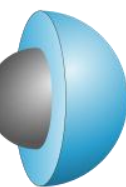
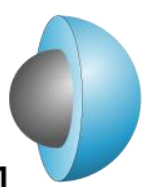
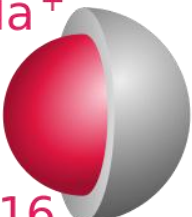

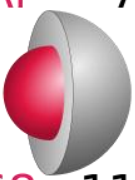

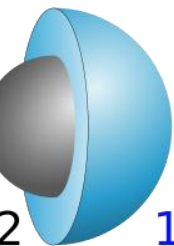
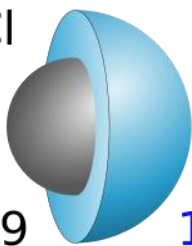

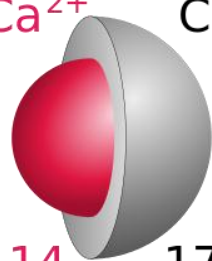

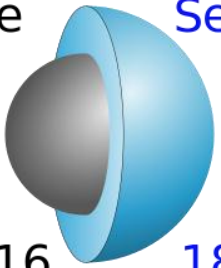
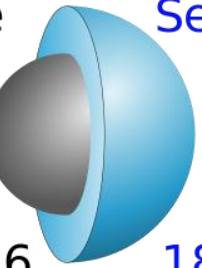
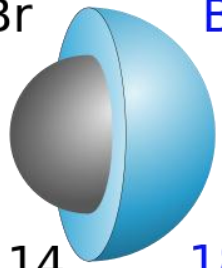
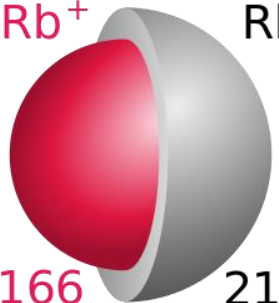

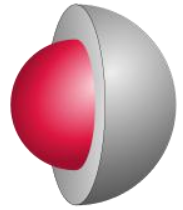
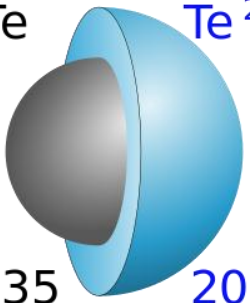
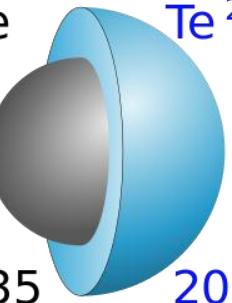
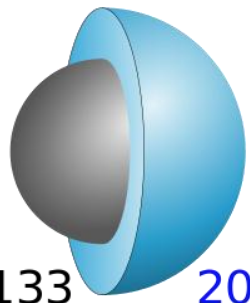


- Down **groups**, the ionic radius will increase.
- Ionic radius follows the same patterns as atomic radius for essentially the same reasons.



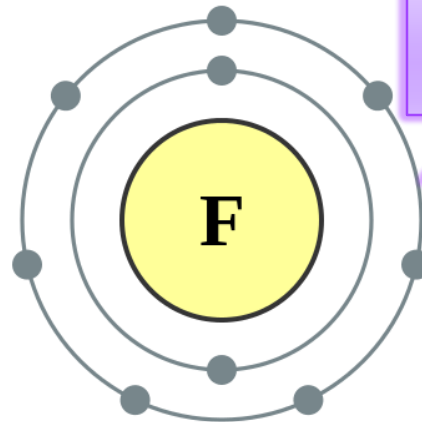
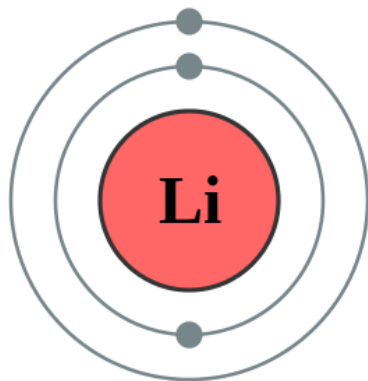
Ionic Radius Illustrated

- Neutral Atomic Radius in Gray
- Cations in Red
- Anions in Blue

Group 1		Group 2		Group 13		Group 16		Group 17	
Li^+  90 Li 134	Be^{2+}  59 Be 90	B^{3+}  41 B 82	O  73	O^{2-}  126 F 71	F^-  119				
Na^+  116 Na 154	Mg^{2+}  86 Mg 130	Al^{3+}  68 Al 118	S  102	S^{2-}  170 Cl 99	Cl^-  167				
K^+  152 K 196	Ca^{2+}  114 Ca 174	Ga^{3+}  76 Ga 126	Se  116	Se^{2-}  184 Br 114	Br^-  182				
Rb^+  166 Rb 211	Sr^{2+}  132 Sr 192	In^{3+}  94 In 144	Te  135	Te^{2-}  207 I 133	I^-  206				

Ionization Energy

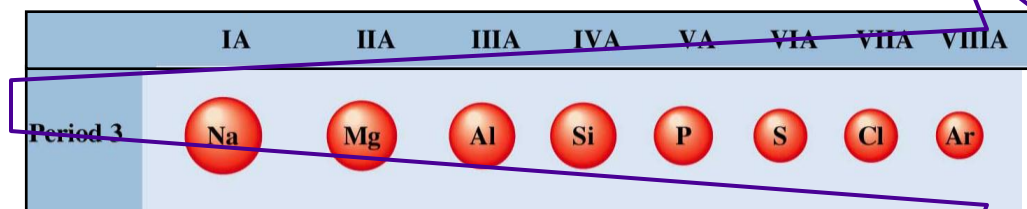
- The outermost shell of the atom is most important, it is the **valence shell** and is responsible for chemical reactivity.
- Every atom wants to have a complete **valence shell**.
- **Ionization Energy** is the energy needed to yank an electron from the **valence shell**.



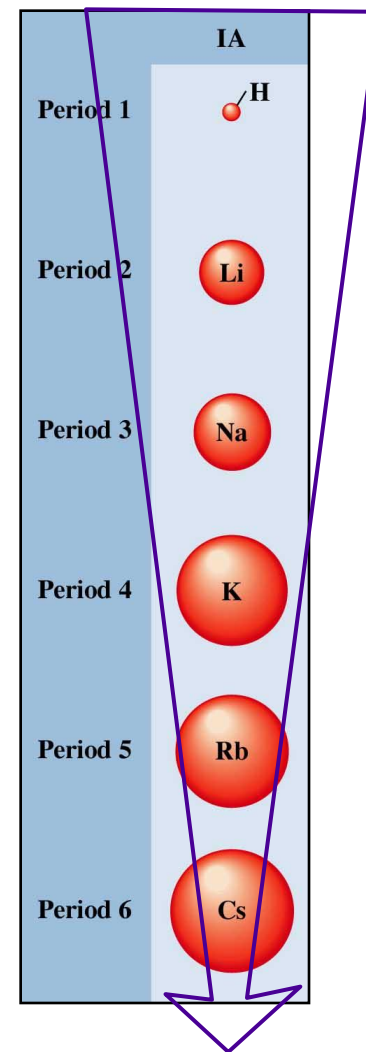
I really want that electron, but at what energy cost?!?!

Ionization Energy Trends

- Across **periods**, the ionization energy increases!



- Down **groups**, the ionization energy will decrease.
- Why? It has to do with the interactions of the nucleus and the electrons! (Again.)



Ionization Energy Explained

- Across a **period** the atomic radius is decreasing.
 - That means the **valence shell** is kept closer and closer to the nucleus.
- The closer the **valence electrons** are to the nucleus, the tighter it can hold onto those electrons!
- Down a **group** the atomic radius is increasing.
 - That means the **valence shell** is forced further and further away from the nucleus.
- The further the **valence electrons** from to the nucleus, the harder it is for them to be held.

Ionization Energy

Increases

Increases

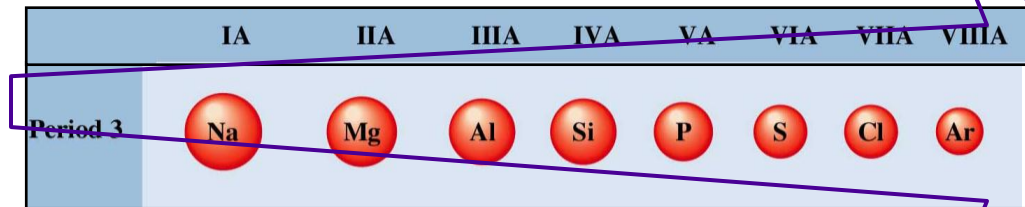
1 H [1.00784; 1.00811] HYDROGEN																	2 He 4.0026 HELIUM						
3 Li [6.938; 6.997] LITHIUM	4 Be 9.0122 BERYLLIUM																	5 B [10.806; 10.821] BORON	6 C [12.0096; 12.0116] CARBON	7 N [14.00643; 14.00728] NITROGEN	8 O [15.99903; 15.99908] OXYGEN	9 F [18.9984032; 18.9984036] FLUORINE	10 Ne 20.180 NEON
11 Na 22.990 SODIUM	12 Mg 24.305 MAGNESIUM																	13 Al 26.982 ALUMINUM	14 Si [28.0855; 28.086] SILICON	15 P 30.974 PHOSPHORUS	16 S [32.059; 32.076] SULFUR	17 Cl [35.446; 35.457] CHLORINE	18 Ar 39.948 ARGON
19 K 39.098 POTASSIUM	20 Ca 40.078 CALCIUM	21 Sc 44.956 SCANDIUM	22 Ti 47.867 TITANIUM	23 V 50.942 VANADIUM	24 Cr 51.996 CHROMIUM	25 Mn 54.938 MANGANESE	26 Fe 55.845 IRON	27 Co 58.933 COBALT	28 Ni 58.693 NICKEL	29 Cu 63.546 COPPER	30 Zn 65.392 ZINC	31 Ga 69.723 GALLIUM	32 Ge 69.723 GERMANIUM	33 As 74.922 ARSENIC	34 Se 78.963 SELENIUM	35 Br 79.904 BROMINE	36 Kr 83.801 KRYPTON						
37 Rb 85.468 RUBIDIUM	38 Sr 87.62 STRONTIUM	39 Y 88.906 YTTRIUM	40 Zr 91.224 ZIRCONIUM	41 Nb 92.906 NIOBIUM	42 Mo 95.94 MOLYBDENUM	43 Tc 97.907 TECHNETIUM	44 Ru 101.07 RUTHENIUM	45 Rh 102.906 RHODIUM	46 Pd 106.42 PALLADIUM	47 Au 107.868 SILVER	48 Cd 112.411 CADMIUM	49 In 114.818 INDIUM	50 Sn 114.818 TIN	51 Sb 121.760 ANTIMONY	52 Te 127.603 TELLURIUM	53 I 126.904 IODINE	54 Xe 131.292 XENON						
55 Cs 132.905 CESIUM	56 Ba 137.327 BARIUM	57-71 LANTHANIDES	72 Hf 178.49 HAFNIUM	73 Ta 180.95 TANTALUM	74 W 183.84 TUNGSTEN	75 Re 186.207 RHENIUM	76 Os 190.233 OSMIUM	77 Ir 192.217 IRIDIUM	78 Pt 195.084 PLATINUM	79 Au 196.967 GOLD	80 Hg 200.59 MERCURY	81 Tl [204.382; 204.385] THALLIUM	82 Pb 204.383 LEAD	83 Bi 208.980 BISMUTH	84 Po 208.982 POLONIUM	85 At 209.987 ASTATINE	86 Rn 222.018 RADON						
87 Fr 223.020 FRANCIUM	88 Ra 226.0254 RADIUM	89-103 ACTINIDES	104 Rf 263.103 RUTHERFORDIUM	105 Dh 262.103 DUBNIUM	106 Sg 266.122 SEABORGIUM	107 Bh 264.125 BOHRIUM	108 Hs 269.134 HASSIUM	109 Mt 268.139 MEITNERIUM	110 Ds 272.146 DARMSTADIUM	111 Rg 272.154 ROENTGENIUM	112 Cn 277 COPERNICIUM	113 Uut 284 UNUNTRIUM	114 Uuq 284 UNUNQUADIUM	115 Uup 288 UNUNPENTIUM	116 Uuh 292 UNUNHEXIUM	117 Uus 294 UNUNSEPTIUM	118 Uuo 294 UNUNOCTIUM						
LANTHANIDES		57 La 138.905 LANTHANUM	58 Ce 140.116 CERIUM	59 Pr 140.908 PRASEODYMIUM	60 Nd 144.242 NEODYMIUM	61 Pm 144.913 PROMETHIUM	62 Sm 150.362 SAMARIUM	63 Eu 151.964 EUROPIUM	64 Gd 157.253 GADOLINIUM	65 Tb 158.925 TERBIUM	66 Dy 162.500 DYSPROSIUM	67 Ho 164.930 HOLMIUM	68 Er 167.259 ERBIUM	69 Tm 168.934 THULIUM	70 Yb 173.043 YTTERBIUM	71 Lu 174.967 LUTETIUM							
ACTINIDES		89 Ac 227.027 ACTINIUM	90 Th 232.038 THORIUM	91 Pa 231.036 PROTACTINIUM	92 U 238.029 URANIUM	93 Np 237.048 NEPTUNIUM	94 Pu 244.064 PLUTONIUM	95 Am 243.061 AMERICIUM	96 Cm 247.070 CURIUM	97 Bk 247.070 BERKELIUM	98 Cf 251.080 CALIFORNIUM	99 Es 252.083 EINSTEINIUM	100 Fm 257.095 FERMIUM	101 Md 258.098 MENDELEVIUM	102 No 259.101 NOBELIUM	103 Lr 262.110 LAWRENCIUM							

Electronegativity

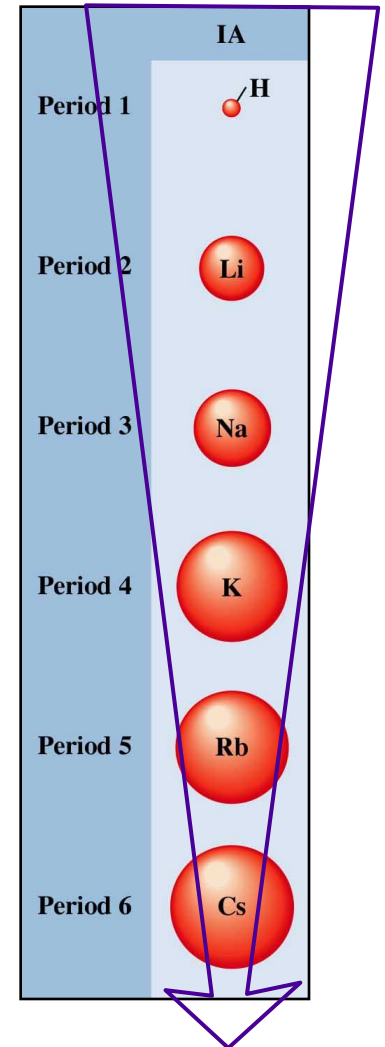
- How attractive is the atom to electrons?
- What kind of force does the atom exert on other atoms as it tries to yank their electrons?

Electronegativity Trends

- Across **periods**, the electronegativity increases!



- Down **groups**, the electronegativity will decrease.
- Why? It has to do with the interactions of the nucleus and the electrons! (Again.)



Electronegativity Explained

- Across a **period** the atomic radius is decreasing.
 - The electron shells are tight and close, exposing more of the nucleus' pulling field or zone of influence to the **target electron**
- The closer the target **electrons** can get to the nucleus, the harder it can pull on them.
- Down a **group** the atomic radius is increasing.
 - That means the **valence shell** is further away and the nucleus is already swarming with electrons – how hard can a nucleus pull when it is already surrounded?
- The further the **target electrons** are from the nucleus, the less force the nucleus can exert on it.

Electronegativity Illustrated

H 2.20																	He
Li 0.98	Be 1.57											B 2.04	C 2.55	N 3.04	O 3.44	F 3.98	Ne
Na 0.93	Mg 1.31											Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16	Ar
K 0.82	Ca 1.00	Sc 1.36	Ti 1.54	V 1.63	Cr 1.66	Mn 1.55	Fe 1.83	Co 1.88	Ni 1.91	Cu 1.90	Zn 1.65	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96	Kr 3.00
Rb 0.82	Sr 0.95	Y 1.22	Zr 1.33	Nb 1.6	Mo 2.16	Tc 1.9	Ru 2.2	Rh 2.28	Pd 2.20	Ag 1.93	Cd 1.69	In 1.78	Sn 1.96	Sb 2.05	Te 2.1	I 2.66	Xe 2.60
Cs 0.79	Ba 0.89	*	Hf 1.3	Ta 1.5	W 2.36	Re 1.9	Os 2.2	Ir 2.20	Pt 2.28	Au 2.54	Hg 2.00	Tl 1.62	Pb 2.33	Bi 2.02	Po 2.0	At 2.2	Rn 2.2
Fr 0.7	Ra 0.9	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup	Uuh	Uus	Uuo
*	La 1.1	Ce 1.12	Pr 1.13	Nd 1.14	Pm 1.13	Sm 1.17	Eu 1.2	Gd 1.2	Tb 1.1	Dy 1.22	Ho 1.23	Er 1.24	Tm 1.25	Yb 1.1	Lu 1.27		
**	Ac 1.1	Th 1.3	Pa 1.5	U 1.38	Np 1.36	Pu 1.28	Am 1.13	Cm 1.28	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.3	Lr 1.291		